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INHIBITION OF MILD STEEL CORROSION IN ACIDIC MEDIUM USING NYPA PALM FRUIT ACETONE EXTRACT

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Abstract: **This is a research work on the inhibition of mild steel corrosion in acidic medium, using Nypa palm fruit extract. The corrosion of metals is a serious problem in many industries, installations and civil services such as water and sewage supplies. One of the most useful and practical methods that is used to control and protect metals against corrosion is the use of inhibitors, especially in acidic media. This study investigated the effective use of Nypa palm fruit extract in epoxy matrix as a bio-based corrosion inhibitor in epoxy coatings for mild steel exposed to acidic solutions. This research was assessed by fourier transform infrared spectroscopy, FTIR and polarization, PDP technique. The fourier transform infrared spectroscopy revealed peaks that corresponds to functional groups, while polarization curves revealed that the extract in epoxy matrix a barrier-layer inhibitor. Inhibition efficiency increased with extract concentration increased up to 1.5g. The results revealed that the extract of the nypa palm fruit in epoxy matrix could serve as an effective inhibitor for the corrosion of mild steel in acidic medium.**

Keywords: **Nypa palm, Epoxy matrix, Mild steel, Corrosion, Acidic media.**

1. INTRODUCTION/BACKGROUND

Due to the remarkable ductility and malleability, mild steel is one of the most prized metals in the industrial world. Its usage in many industrial processes and structures makes it vulnerable to corrosion, particularly when put through industrial procedures like etching, pickling, acid washing, etc.

The development of technology was sparked by the right use of these metals' powers, which it used to do various tasks within the web of their capabilities. Because they gave humankind precise instruments with unmatched qualities for use in both battle and their preparation and processing, metals have attracted mankind for many years.

However, the pleasure brought about by the usage of metals is short-circuited by a danger known as corrosion. This threat impairs it, decreasing its effectiveness of the metal, which terrifies it with some horrifying traits as a sharp decrease in its malleability and ductility.

Many definitions have been proposed to adequately describe corrosion, which has undermined the usefulness and benefits of metals to mankind. Corrosion is a natural potential danger connected to industrial processes and transportation facilities. It may be simply described as the destructive attack of a substance through interaction with its environment (Papoola et al., 2013).

However, a more thorough definition refers to it as a physical interaction between a metal and its environment that alters the metal's properties and may seriously impair the functionality of the metal, the environment, or the technical system that it is a part of. Regardless of how it is described, the process basically involves the degradation or destruction of metals or alloys via chemical or electrochemical methods while in the presence of an environment.

The aim of this study is to investigate the corrosion inhibition effect of Nypa palm fruit extract in epoxy matrix as a cheap and environmental friendly corrosion inhibitor for mild steel in 1M HCl medium by FTIR and PDP measurements.

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2. EXPERIMENTAL SECTION

Materials used for the study: mild steel sheet, nypa palm fruits, tap and distilled water, acetone, weighing balance (adventure), 1200◦c capacity oven, soxhlets extractor, rotary evaporator, binder (epoxy), heating device, glass conical flask, glass funnel, filtering paper, grinding engine, Potentiostat/Galvanostat (FRAS2M AUTOLAB) for Potentiodynamic Polarization (PDP) and FT/IR-88 JASCO for fourier transform infrared spectroscopy, FTIR.

Preparation of extract: the extract of nypa palm fruit (fruticans) was prepared by using soxhlet and rotary evaporator apparatus using acetone as a solvent for 48 hours. 4kg of nypa palm fruits in natural state were air dried for 7 days. Then grinded to powdered form. 444g of finely powdered material was taken in a 1000ml round bottom flask and enough quantity of acetone was added to cover the powder completely. The round bottom flask was covered with a foil paper and left for 72 hours for excellent extraction. Then it was filtered. Then the resulting paste was refluxed for 24 hours. Then it was filtered using a soxhlet extractor with the RBF sitting in a heating device and then, rotary evaporator.

Fourier transform infrared spectroscopy (FTIR): FTIR analysis was conducted on the extract to ascertain the presence of functional groups in the nypa palm extract, which should determine if the research should be continued or discontinued. Hence, it is only plant extracts rich in functional groups that inhibits corrosion.

Preparation of electrode (mild-steel): Mild steel electrodes were purchased and subjected to composite (spark) analysis, to ascertain the percentage purity of the coupons, 99.6%.

Then the metal coupons were cut to, thickness: 2.20mm, width: 10mm and further sand papered with different grades of emery clothes, between P220 to P1,200 to obtain smooth substrates of the specimen. Each of these coupons were degreased by ethanol and air-dried before preservation in desiccator. A total of 7 electrodes were prepared, 2-out of the 7 were used as the controls, blank uncoated and coated with epoxy resin (matrix) alone.

Preparation of epoxy resin and nypa palm fruit acetone extract: two ratio one (2:1) of epoxy resin and catalyst in ration of 3ml syringe mixed with different grams were mixed alone. then

two ratio one (2:1) of epoxy resin in ratio of 3ml syringe mixed with different grams of the extracts, ranging between 0.3g, 0.6g, 0.9g, 1.2g and 1.5g were prepared and were thoroughly stirred until homogenous mixtures were obtained.

Coating of the electrodes: one of the electrodes was not coated, one was coated with epoxy resin alone and the remaining five were coated in the order of 0.3g, 0.6g, 0.9g, 1.2g and 1.5g. After the coating, the coupons were air dried for 48 hours.

Potentiodynamic polarization analysis: the potentiodynamic polarization measurements were carried out in conventional three electrodes cell using Potentiostat/Galvanostat (FRAS2M AUTOLAB) model instrument. The potential of the test electrodes was measured with respect to SCE and platinum was used as auxiliary and the experiment were carried out at room temperature.

3. RESULTS AND DISCUSSIONS

Table 1: Results of fourier transform infrared spectroscopy (FTIR) analysis of the nypa palm fruit acetone extract (NPFAE) sample.

SN	Peak	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area
1	879.57	97.45	0.0579	887.28	725.26	1.8437	0.0655
2	918.15	97.2807	0.6861	1041.6	887.28	1.6310	0.3037
3	1211.34	95.5307	1.1264	1450.52	1172.76	3.1653	0.4898
4	1496.81	98.3609	0.3165	1573.97	1450.52	0.9721	0.1041
5	1712.85	94.5859	3.9206	1797.72	1573.97	2.4202	1.487
6	1820.86	97.6526	0.4861	1944.31	1797.72	1.4839	0.1321
7	2106.34	98.0156	0.1001	2198.92	2060.04	1.0948	0.0322
8	2337.8	96.7397	1.241	2430.39	2252.93	2.1317	0.4585
9	2476.68	97.7231	0.1253	2515.26	2430.39	0.9637	0.0249
10	2615.56	97.5874	0.0583	2630.99	2515.26	1.3920	0.0088
11	2715.86	97.4218	0.1203	2762.16	2669.57	1.4734	0.0203
12	2777.59	97.4296	0.187	2831.6	2762.16	0.0783	0.0278

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13	3016.77	96.789	0.6835	3047.63	2916.47	1.3128	0.2673
14	3248.23	96.0168	0.8397	3333.1	3124.79	3.4302	0.3937
15	3394.83	96.845	0.136	3410.26	3356.25	0.8326	0.0187
16	3471.98	96.7425	0.099	3495.13	3456.55	0.5631	0.0081
17	3564.57	96.8263	0.4677	3680.3	3541.42	1.4048	0.18
18	3811.47	98.5528	0.1837	3850.04	3772.89	0.6254	0.0322

Table 1 above showed the fourier transform infrared spectroscopy (FTIR) analysis of the extract for functional groups showing the peak, reaction type, functional group and their strong presence.

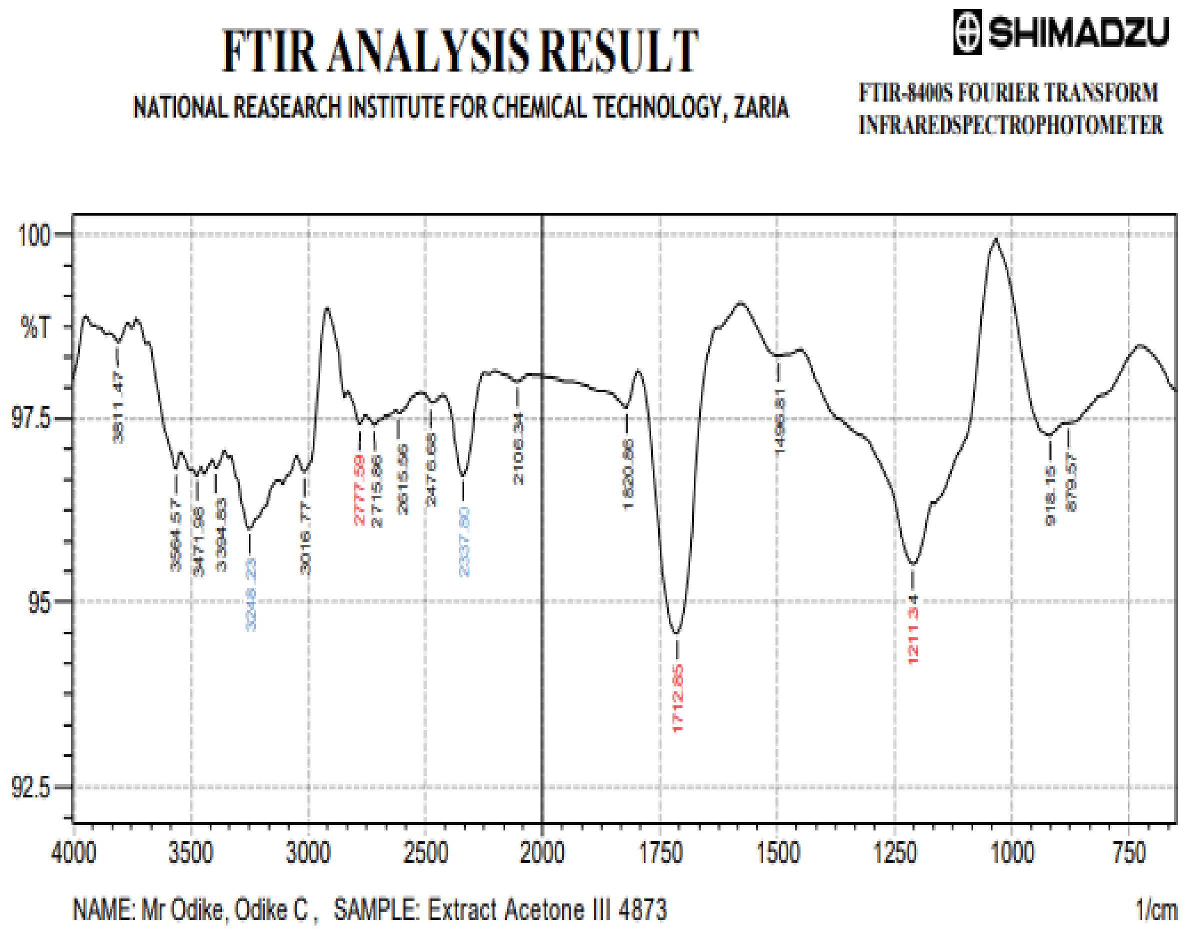

Figure 1: fourier transform infrared spectroscopy (FTIR) Graph for NPFAE

Table 2: Potentiodynamic polarization (PDP) parameters

System	E_{corr}	I_{corr}	βa	βc	θ	IE
	mV/Ag/AgCl	μAcm^{-2}	$mVdec^{-1}$	$mVdec^{-1}$		%
Blank uncoated MS	-457	1792	74	118	-	-
Blank epoxy coated	-467	1021	62	101	0.430	43.0
0.3 % NPFAE/ epoxy coated	-469	1141	65	99	0.363	36.3
0.6 % NPFAE/ epoxy coated	-414	1132	63	97	0.368	36.8
0.9 % NPFAE/ epoxy coated	-460	604	59	99	0.663	66.3
1.2 % NPFAE/ epoxy coated	-513	102	41	218	0.943	94.3
1.5 % NPFAE/ epoxy coated	-550	164	48	198	0.908	90.8

Table 2 showed the potentiodynamic polarization (PDP) parameters relating to mild steel for blank uncoated and epoxy coated with and without the different concentrations of NPFAE corrosion inhibitor in epoxy matrix tested in 1M HCl corrosive environment at room temperature.

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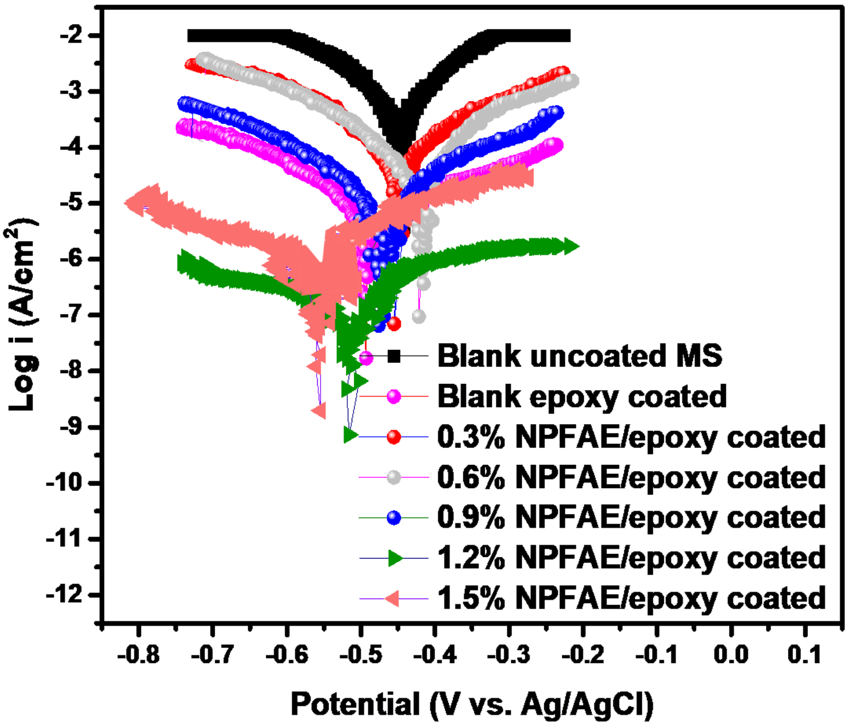

Potentiodynamic polarization (PDP) analysis of mild steel for blank uncoated and epoxy coated with and without the different concentrations of NPFAE corrosion inhibitor embedded in epoxy matrix tested in 1M HCl corrosive environment.

4. DISCUSSION

Results from Table 1 of the Fourier Transform Infrared Spectroscopy (FTIR) analysis for the NPFAE samples show various peaks corresponding to different functional groups and bond vibrations.

The NPFAE sample display peaks within the vicinity of the standard C = C bending region, indicating the presence of vinylidene and alkane functional groups. NPFAE shows strong peaks close to the standard values, confirming these functional groups. NPFAE shows peaks at 1211.34 and 1712.85 cm^{-1}, aligning well with the C = O stretching for vinyl ether and carboxylic acid. NPFAE displays peaks consistent with N-O and N=C=S stretching, as per the standards, suggesting the presence of nitro compounds and isothiocyanates. NPFAE has a more complete representation of these functional groups than NPFDE.

NPFAE aligns closely with the standard peaks for O-H stretching, indicating the presence of alcohols and carboxylic acids.

NPFAE shows multiple C-H stretching peaks that align well with the standard, indicative of aldehyde and alkane groups. NPFAE has a strong alignment with the FTIR standards, showing the presence of various functional groups including vinyl ether, nitro compounds, aldehydes, carboxylic acids, and alcohols. The high intensity and proximity of its peaks to the standard values confirm the presence of these groups.

The FTIR analysis reveals that NPFAE is chemically complex, with a closer resemblance to the FTIR standards, indicating a richer composition of functional groups. This could mean NPFAE has a broader range of potential reactivity and application versatility.

Results from Table 2 showed the potentiodynamic polarization (PDP) parameters relating to mild steel for blank uncoated and epoxy coated with and without the different concentrations of NPFAE corrosion inhibitor in epoxy matrix tested in 1M HCl corrosive environment at room temperature.

Inhibition Efficiency (IE): The blank epoxy coating achieves 43% IE, while NPFAE-epoxy coatings show improved IE with increasing concentration, reaching 94.3% IE at 1.2% NPFAE and 90.8% IE at 1.5% NPFAE. This demonstrates that NPFAE acts as a highly effective corrosion inhibitor, especially at concentrations around 1.2%. NPFAE in epoxy coatings significantly enhances the corrosion protection of Mild Steel in acidic environments. A concentration of 1.2% NPFAE shows the highest IE at 94.3%, indicating optimal performance. The shift demonstrated that NPFAE reduces the corrosion rate, likely by forming a protective layer that prevents acid penetration to the Mild Steel surface.

Inhibition Efficiency (IE): NPFAE in epoxy coatings significantly enhances the corrosion resistance of Mild Steel in 1M HCl. The results indicate that 1.5% NPFAE yields a high corrosion inhibition (96.4%), making it an excellent choice for corrosion protection. Inhibition Efficiency.

(IE): The blank epoxy coating achieves 43% IE, while NPFAE-epoxy coatings show improved IE with increasing concentration, reaching 94.3% IE at 1.2% NPFAE and 90.8% IE at 1.5% NPFAE. This demonstrates that NPFAE acts as a highly effective corrosion inhibitor, especially at concentrations around 1.2%. NPFAE in epoxy coatings significantly enhances the corrosion protection of Mild Steel in acidic environments. A concentration of 1.2% NPFAE shows the highest IE at 94.3%, indicating optimal performance. The shift demonstrated that NPFAE reduces the corrosion rate, likely by forming a protective layer that prevents acid penetration to the Mild Steel surface.

NPFAE, indicating effective corrosion inhibition.

5. CONCLUSION

The research work demonstrated that Nypa Palm Fruit Extracts (NPFAE), when incorporated into an epoxy matrix, is an effective corrosion inhibitor for mild steel in acidic environments. The potentiodynamic polarization (PDP) analyses reveal that NPFAE significantly enhances the corrosion resistance of mild steel by reducing the corrosion current density and increasing the charge transfer resistance. Notably, the inhibition efficiency (IE) improves with higher NPFAE concentrations, reaching a maximum of 96.4% for mild steel NPFAE concentration.

The protective mechanism appears to be due to the formation of a barrier layer on the metal surface, which limits the interaction of the corrosive medium with the metal. This bio-based corrosion inhibitor not only exhibits strong protective properties but also offers an environmentally friendly alternative to traditional synthetic inhibitors, aligning with the growing demand for sustainable corrosion protection methods in industry.

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